Disseminating Knowledge of Wildfire Using a Geographic Information System: Three Case Studies

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The Country Fire Authority of Victoria is developing a Wildfire Threat Assessment program which is specifically designed to provide CFA Operations management with access to databases that support strategic operational decision making by analysing information on wildfire behaviour, population and fire statistics.

Additional benefits have accrued from the program by using a number component databases in other forums. The utility of modern information systems lies in their ability to compress and integrate a number of varied and perhaps complex data sets such that the yields are understandable to a larger audience than would be the case if they were dealing with the raw data and mathematics.

In Victoria, many groups with an interest in wildfire are beginning to utilise the products of information systems to improve their comprehension of wildfire processes and understand how it may affect their own environment.

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INTRODUCTION

A Geographic Information System (GIS) is a computer system which is capable of combining several layers of geographical data to produce outputs in the form of summary statistics and maps. Geographic data is data which can be related to specific locations on the earth's surface. Roads, rivers, soils, vegetation and topography are examples of geographic data that are now capable of being analysed and integrated to produce value added information sets.

The utility of GIS technology lies with the fact that many scenarios can be viewed at the computer screen or as paper plots; each scenario altering a variable to determine the impact of that change on the overall output. When properly constructed and presented, outputs from the GIS (tables, reports and thematic maps) that summarise sometimes complex operations allow groups from varied backgrounds or levels of expertise to gauge the contribution that each component may have on an outcome.

In the past few years there has been an enormous growth in the availability of geographic data suitable for computer analysis at a price that is within the reach of most Government Departments. Examples in Victoria include statewide coverage of data such as topography, census data, road networks and cadastral boundaries. Data sets derived from satellite imagery and aerial photography such as vegetation, soils and built-up areas are also available.

There is presently a confluence of data availability, cost effective hardware and software in the GIS arena. It is enabling an increasing number of groups to analyse complex problems and allow for the results to be presented to a much wider audience.

THE COUNTRY FIRE AUTHORITY'S WILDFIRE THREAT MODEL

The CFA's interest in wildfire threat assessment using computer techniques began in the mid 1980's with the commissioning of a project to develop a threat assessment model for structural fires. During the development of this model it was acknowledged that a separate approach was necessary to model wildfire threat.

The analysis of threat is a precursor to more efficient application of resources resulting in a safer wildfire environment for Victorians. Once threat has been characterised and mapped, a number of moderating strategies such as deploying firefighting resources more effectively, identifying high threat areas where building construction practices can be modified and targeting education programs can be applied to increase survivability.

The need for improved information on the spatial distribution of wildfire threat has led to the development of the Wildfire Threat Model (WTM). A number of techniques already in use elsewhere in Australia were reviewed for their applicability to Victoria. However, they generally did not include life values or the built environment as their focus, features which are the legislated responsibility of the CFA.

The aim of the CFA's WTM is to develop an appropriate database and rationale for assessing the requirements for fire prevention and suppression resources throughout Victoria. It will provide CFA management with a profile of the wildfire threat across the state. As well as giving a generalised classification, the model will deliver specific information on population, dwellings, terrain, wildfire behaviour, and wildfire statistics. This will, in turn, enable objective analysis of the current wildfire brigade structure and identify areas which may require specific fire protection or fire prevention strategies.

The WTM reflects the CFA's view of wildfire threat and is thus inclined toward the protection of life and property. This view of threat may not necessarily coincide with that of other services or communities where other values vulnerable to fire, such as flora and fauna, may have precedence.

The WTM and the various products derived from the databases are to be used at a number of scales. At a statewide level, WTM will enable review of wildfire equipment levels and fire brigade structure and possibly assist in the designation of wildfire-prone areas. At a regional level the WTM provides input into short and long term regional planning processes and at its largest scale the WTM will assist in solving local issues such as the identification of areas unsuitable for development due to high loss potential and in providing an insight into the physical processes of wildfire at community group meetings.

The WTM is comprised of three modules :– Fire Behaviour, Damage Potential and Fire Statistics. The Fire Behaviour module combines vegetation data, litter weights, topography, low fuel areas and weather analysis in the GIS to produce a map of potential fire intensity. The Damage Potential module analyses the density of population and dwellings, and the agricultural productivity of a region whilst the Fire Statistics module examines wildfire statistics over a period of ten years. The three modules are then weighted and combined in a final layer — the Wildfire Threat Index.

Wildfire threat mapping — its use by CFA officers

CFA users of WTM maps analyse overall wildfire threat categories but also study fire intensity, population, housing and fire statistics maps to understand how each of the base maps contribute to the overall threat. For example, there may be a relatively high density of people or a large number of fires within a particular area and these can be studied and compared across a geographic area. The WTM is used as a planning tool both at the strategic or statewide level as well as at the local level. It will support management decisions regarding the formation of brigades, and the types and amounts of equipment.

At CFA Regional headquarters, fire threat maps are analysed along with the present fire brigade structure. This is undertaken to identify areas where the threat is high and coverage or performance is low. Strategic plans and annual plans would be adjusted to relieve shortcomings in the present structure.

OTHER USES OF GEOGRAPHIC INFORMATION SYSTEM-GENERATED MAPS

Plenty Gorge planning scheme amendment

The CFA often makes submissions at Planning Tribunals in high fire threat areas so that factors influencing the safety of residents and firefighters are reviewed by Tribunal members. Often CFA Officers present cases based on the intricacies of wildfire science such as the integration of meteorology, topography and vegetation and their contribution to fire behaviour to Panel members who are not familiar with basic wildfire behaviour principles.

Such a Planning Appeals Tribunal (Diamond Valley Planning Scheme Amendment L46) recently occurred reviewing development in the Plenty Gorge, approximately 40 kilometres to the north of Melbourne. Applications had been made to subdivide land within the gorge area. The CFA was of the view that because of the possibility of extreme wildfire behaviour consideration should be given to road widths and allotment size in the gorge.

A series of maps were produced to support a CFA case. The maps consisted of a base potential fire intensity map, and transparent overlays of slope, vegetation, aspect and current administrative boundaries. Fire Intensity is a main factor in increasing the wildfire threat. The greater the intensity, the more difficult it is to suppress a fire, the more damage it will inflict, and the more vulnerable a community in the path of that fire will be.

The following edited text is taken from the CFA's written submission to the Panel members by CFA Regional Officer Greg Flynn (Flynn 1994):

"(the Fire Intensity Maps) show diagrammatically the way in which the fire intensity map is compiled. Fuel weights that have been used for the calculations are 3 tonnes per hectare for grasslands and 20 tonnes per hectare for forest areas. They are representative of the growth, and resultant fuel weights likely to occur in this area in an average season. The Fire Danger Indices chosen for the calculations are 32.6 for grassland and 24.4 for forest. These FDI's have been chosen from statistical analysis of daily weather data for Melbourne from 1938 to (55 years) 1993 and then selecting the 95th percentile point for fire danger rating. ie It is likely that only five percent of days would experience higher fire danger ratings.

Fire Intensity is a measure of the degree of difficulty that firefighters would encounter in fire suppression activities. It is recognised that firefighters have the capability to mount a head on attack at a running wildfire up to 4000 kW/metre of energy. However, they are generally limited to an attack from the sides with fires generating between 4000 and 15000 kW/metre of energy. Fires generating more than 15,000 kW/metre are considered uncontrollable and other firefighting strategies are must be employed to protect life and property.

Looking at the map shows that the great majority of the sloping land in the vicinity of the gorge would carry a fire under the prescribed conditions of such an intensity that an effective control strategy could not be put in place until the fire came out of the gorge. Most of the sloping land has a fire intensity of 10000 kW/m or greater. Given the difficult access in much of this area I suggest that a fire of this intensity would be difficult to control here. This reinforces the need for the property owners to take the initiative and do the necessary fire prevention works to protect their own properties.

The map also indicates that most of the 'flat' land adjacent to the gorge will also carry a fire of significant intensity. This includes the great majority of land affected by Amendment L46 and again indicates the need for individual property protection. Obviously the amount of work required to achieve similar levels of protection in these flatter areas is not the same as that required to ensure the safety of similar houses in the gorge proper.

The Fire Intensity map is compiled of a series cells that represent an area on the ground of 100 metres by 100 metres. It defines clearly the areas of greatest hazard and may provide opportunity to review quite closely the potential effect that fire may have on any specific area. From the small on the ground cell size it can be seen that it is quite detailed, however it is only another tool to assist in planning our approach to fire prevention and suppression. It does not for example indicate any effects that fire spotting may have adjacent to the gorge. History indicates that this can be significant given the right conditions.'

Panel decision

The Panel handed down a decision which was in line with the CFA's submission i.e. subdivisions were restricted to 2 hectares in size and a number of fire prevention measures are to be included in the development. The Panel's written summary of the proceedings drew much from Flynn's (1994) written presentation.

The panel had first studied standard methodology for reviewing fire threat in the Gorge but found the GIS generated maps more reliable and understandable. To quote the Panel (Mitchell and Lewin 1994): '(we) found the Plenty Gorge Fire Intensity Map invaluable in assisting it in its deliberations on L46'.

Community fireguard

Community Fireguard is a community education program designed to reduce the loss of lives and homes in bushfires. The program is based on the fact that many people will have to face a wildfire without the support of the CFA, which cannot provide every person and home with individual protection during a major bushfire. It presumes that bushfires are survivable, provided communities take responsibility for their own safety.

Community Fireguard is made up of small groups. These may simply be a dozen or so neighbours living in an area where the threat of fire is high, or they may be an existing group such as Landcare or a conservation group which is interested in reducing the fire threat. Either way, with support from the CFA and by working together, these people find they can develop strategies which are simple, inexpensive and effective and can save lives and homes.

They also want to know what to expect from the emergency services and what the fire is going to look, sound and feel like if they are caught in the middle of it. Armed with this understanding, the groups can make decisions about the best way to protect themselves in a way that fits their lifestyle, environment, physical capabilities, finances and experiences.

To help groups find strategies for reconciling fire safety with other management objectives, Community Fireguard facilitators help groups to understand the experience of a major fire. Before deciding how best to tackle the fire threat, people need an understanding of how houses are destroyed by fire, how and why people die in fire and how a fire behaves.

A series of maps of potential fire behaviour has been generated for Community fireguard groups. People are most vulnerable to high intensity fire, and the potential fire intensity maps generated by the WTM are useful in identifying areas where the prerequisites for high intensity fires exist.

The maps are graphic, easily comprehended representations of potential fire behaviour. Because the map integrates slope, fuel and weather components, and presents the

resulting fire intensity in a simple format it can be especially useful early in the program when the Community Fireguard participants have little understanding of the science behind fire behaviour.

The relatively large scale of the Fire Intensity maps is also advantageous as it allows residents to put their threat into context by comparison with other local geographic areas that they are familiar with. The similarities or differences in potential fire intensity can then be the starting point for discussing fire behaviour, e.g. Why is the potential for fire higher in this street than that one? Because one is on flat ground and the other is on the side of a hill.

Fire Intensity maps can become resources that residents can use when dealing with major land owners, such as government departments, who they may feel are not giving high enough priority to fire prevention works in their locality. Being able to use such tools helps them to be treated as stakeholders who have a substantial understanding of fire behaviour principles.

YarraCare

YarraCare is a community based program dealing with the management of the Yarra River catchment. It aims to identify priority land and waterway issues in the catchment and define the need for action. More than sixty community representatives participate in the formal YarraCare group meetings, forming a partnership with all key government agencies.

The Land Management series of papers addressed a number of issues that contribute to the decline in the water quality of the Yarra and its tributaries. The papers provided both the community and agencies with the opportunity to discuss the issues for future management of the catchment.

A paper describing the potential impact of bushfires on the environment and the people of the Yarra Catchment was prepared by Stephen Petris of the CFA (Petris et al. 1994). Wildfire threat is particularly high in parts of the Yarra Catchment due to a combination of relatively large population, rugged topography, poor road access and egress, high fuel loads and periodic extreme fire weather.

This is confirmed by the number of fires experienced in the Yarra Catchment. On Ash Wednesday 1983, for example, two major fires ravaged the catchment. The Cockatoo fire took six lives and destroyed 307 houses, whilst the Warburton fire burnt 40,000 hectares, destroying 27 homes. In 1962, fires at The Basin/Olinda, Christmas Hills, Chum Creek, Kinglake, St. Andrews, Hurstbridge, Warrandyte and Woori Yallock took 8 lives and destroyed 454 houses. Fires in the Basin/Olinda area burnt another 53 houses in 1968. In addition to the loss of human lives and assets, these fires also destroyed native and farm animals and their habitats, and caused pollution in water supplies.

Two topics were given particular attention. Firstly the paper developed a theme to assist the understanding of factors that contribute to fire threat by describing the concept of fire intensity, and secondly the paper described the effects of wildfires on both the natural environment and on communities, while discussing how communities can develop strategies to reduce the wildfire threat. A series of GIS-generated potential fire intensity maps were included in the report.

Petris developed the theme of fire intensity as contributing substantially to the wildfire threat faced by communities in the catchment. Part of the text (from Petris et al. 1994) follows:

'Fire Intensity is an important factor in determining the impact of fire on human communities. Earlier in this report the intensities at which suppression forces can stop the forward spread of major fires was discussed. The Potential Fire Intensity map for the Yarra Catchment indicates that, for large parts of the catchment, on a day of very high fire danger, expected fire intensities are greater than that which can be controlled by sup-

pression forces. On extreme fire days, when fire intensities are greater again, fire suppression agencies recognise that there is very little can be done to stop the forward spread of a major fire until weather conditions moderate, or until fire run into areas of low fuel e.g. areas recently fuel reduced.

On these days one of the most effective suppression strategies is to extinguish fires before they become large enough to threaten life and property. This was confirmed by the experience of the Ash Wednesday Fires in Victoria in 1983. Of the 180 fires that started on that day, suppression forces were able to extinguish 172 before they caused significant damage. However those fires that could not be quickly suppressed on these days rapidly reach intensities too high to be controlled.

Fortunately, there a many ways communities can reduce the threat to their lives and homes from major wildfires. A study by Wilson (1984) for example identified fire intensity as the most important factor in determining whether houses were destroyed by the Mount Macedon fire on Ash Wednesday. Residents can reduce the intensity of a fire as it passes by reducing the amount of available fuel. This can simply be achieved by reducing the amount of twigs, leaves, dry grass and bark around their homes and communities. Alternatively, the amount of available fuel may be reduced by keeping gardens and parks green during the fire danger period.'

Once again techniques first developed for the CFA's Wildfire Threat Mapping program substantially enhanced the notion and understanding of fire behaviour principles by providing a visual output of the combination of variables that contribute to wildfire threat.

CONCLUSION

The utility of Geographic Information Systems lies in their ability to compress and integrate a number of varied and perhaps complex data sets such that the yields are understandable to a larger audience than would be the case if they were dealing with the raw data and mathematics.

Many fire management groups across Australia are beginning to utilise GIS in the study of fire processes. Many more groups are beginning to see the products of GIS to improve their comprehension of wildfire and how it may effect them.

The CFA has established a wildfire threat analysis program that is providing a number of GIS based products facilitating more effective and responsible management of wildfire.

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